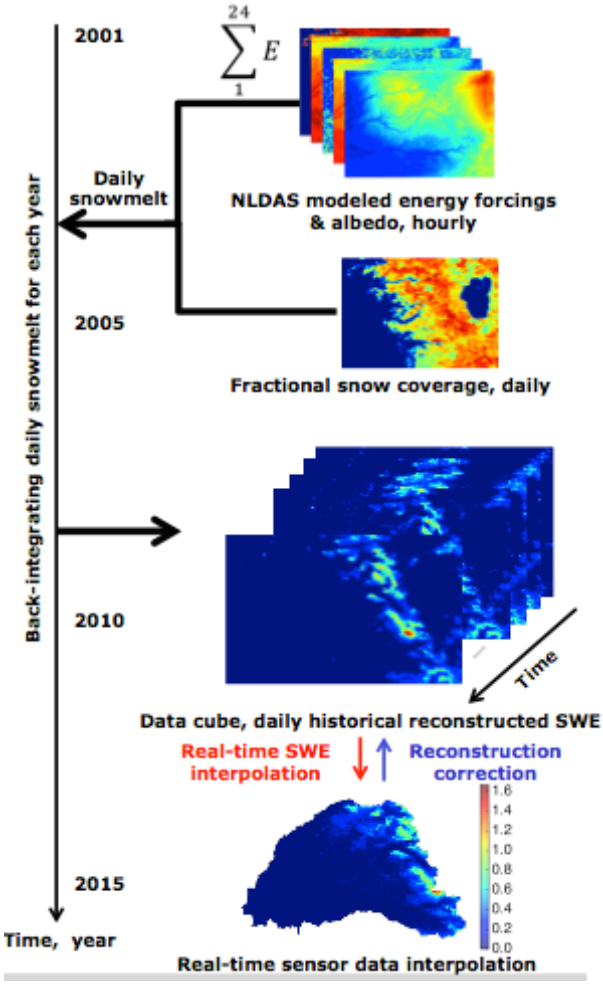
# A real-time spatial snow water equivalent (SWE) estimation system of the American River Basin

**Z Zheng, R Bales, S Glaser, M Conklin**

1. The essence of this research is to build a cyber-physical system that could estimate snow water equivalent in real time.
   1.1. Cyber – Just like the human brain, it is the computation central that stores all the historical memories of the SWE condition in the basin, collects real-time SWE readings from sensor networks, and calculates the SWE over the entire basin based on the available information.
   1.2. Physical – Wireless sensor networks that monitor environmental conditions in the American River Basin. They report snow, temperature, relative humidity, etc. in real time to the cyber component of the system.
2. Model formulation
   See Figure 1.




3. Validation and uncertainty of the model
   3.1.
   Assuming the snow density as a constant value ($0.33\times10^3$ kg/ $m^3$) through

   the season, the root mean squared error of the cross validated SWE estimation is about 15 cm. The application of the cybern physical system is validated.

   3.2. Since snow density was assumed as a constant in the validation, which is not true, uncertainty was introduced into the model validation. Further research

show that snow density is found correlated with days of the water year, temperature, and precipitation. Therefore, a random forest model was built to investigate the spatial-temporal patterns of snowpack density. The cross-validation error of the model is about $0.01\times10^3$ kg/m$^3$, which is about 2% of the mean snowpack density through the season. This snowpack-density modeling component has not been integrated with the SWE estimation system. It could be expected that the root-mean-squared error would be decreased further as it is integrated.